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Synoptic Note on

"Image based Plant Disease Detection and Classification with the Application to Pigeon pea leguminous shrub"

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Synoptic Note

Title of the Research :	Image based Plant Disease Detection and Classification with the Application to Pigeon pea leguminous shrub.
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Abstract

Agriculture is one of the major players in the economy and it is the backbone of the country. Major section of the production is diminished by the presence of diseases in the plants grown. Plant disease can be described as some form of modification that hampers the normal processes in it. Crop production can be majorly affected by these diseases which may reduce the quality and quantity of the overall produced yield. Management of large amount of crop yield involves various timely activities such as keeping a watch for diseases, which reduces it to undesirable stuff. It also involves finding immediate cure for various challenges faced. Plant diseases are studied in the literature to make predictions based on the visible surface of plants and leaves using image processing and machine learning techniques. In recent years, many methods have been proposed in the literature for plant/herb leaf detection and classification for different plants/herbs. These methods helps agriculture sector for effective management of disease identification and take appropriate steps for the treatment thereby increasing the crop production. However, not much work has be done in the case of Pigeon pea plant disease detection and classification.

Pigeon pea is a major crop in north Karnataka as it contains suitable climate requirement and soil type. Earlier, pest and disease detection was done by manual observation. This method is arduous and prone to error. In order to improve the quality of production and yield in plants, it is essential to identify the symptoms in their initial stages and treat the disease. This also reduces the amount of pesticides spraying in the farm and reduces the soil pollution. Our proposed research work involves creation of the Pigeon pea crop dataset with the help of experts and develop effective techniques using machine learning concepts for Pigeon pea plant disease identification and classification. The purpose help farmers to detect, diagnose and treat diseases at early stages thereby help achieving high crop yield and quality.

1. Introduction

In recent years, agricultural productivity has significantly increased, due to the use of improved farming practices like Precision Agriculture. In general, Precision Agriculture involves better management of farm inputs (like fertilizers and herbicides) by applying the right management practice at the right place and at the right time. This is very important considering the fact that under conventional farming, large farm fields usually receive uniform applications of fertilizers, herbicides, irrigation etc, while they may not need to. With the use of precision Agriculture, a field can be divided into management zones that each one receives a customized management. In Precision farming approach real time data is captured to increase crops productivity and maintain the quality of crops.

Agriculture is facing tremendous challenges including the changing climate, severe short fall of arable land and water resources, as well as the threat from diseases, pests and weeds. Major section of the production is diminished by the presence of diseases in the plants grown. Plant disease can be described as some form of modification that hampers the normal processes in it. Crop production can be majorly affected by these diseases which may reduce the quality and quantity of the overall produced yield. Management of large amount of crop yield involves various timely activities such as keeping a watch for diseases, which reduces it to undesirable stuff. It also involves finding immediate cure for various challenges faced. Disease can affect the overall functional capacity of the plant. It may result in reduced growth, less fruit production, more leaf falls and many other ailments also. The disease may spread from crop to crop or may be spread by some pathogen or other means. The disease may be caused by some fungi or some bacteria or even viruses get transferred with seeds from one place to another. Effective ways of detection of disease in plants is crucial. Early and accurate diagnosis of plant disease is one of the pillars of precision agriculture.

Plant diseases are studied in the literature to make predictions according based on the visible surface of plants and leaves. Detection of diseases as soon as they appear is a vital step for effective disease management. The detection is traditionally carried out by human experts. Human experts identify diseases visually but they face some difficulties that may harm their efforts. In this context, detecting and classifying diseases in an exact and timely manner is of the great importance. Advances in artificial intelligence researches now make it possible to make automatic plant disease detection from raw images. The objective of the proposed research is to develop efficient AI system to detect plant disease with application to pigeon pea plant.

1.2 About the Pigeon pea plant

Pigeon pea (*Cajanus cajan* (L.) is one of the protein rich legumes of the semi-arid tropics grown throughout the tropical and subtropical regions of the world. Pigeon pea is a highly branched shrub with a woody base, slender stems and trifoliate leaves. The plant leaflets are oblong or elliptical in shape and the leaves are alternate and arranged spirally on the stems. The plant usually produces yellow flowers, but they can be yellow with streaks of purple or red. The flowers are produced on racemes of 5–10 flowers. The seed pods are flat and either straight or sickle shaped and measure 5–9 cm (2–3.5 in) in length. Each pod can contain between 2 and 9 seeds

which can be white, cream, brown, yellow, purple or black or mottled with any combination of these colors. Pigeon pea can reach 0.5–4.0 m (1.6–13.1 ft) in height and is usually grown as an annual, harvested after one season. It may also be referred to as red gram or congo pea and originates from India.

India is the largest producer of pigeon pea accounting for 66 percent of total production of the world. Economically it is the second most important pulse crop after chickpea in India accounting for about 20 percent of total pulse production. Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat, Andhra Pradesh, Tamilnadu and Bihar are the major growing states (www.agricop.nic.in). Pigeon pea is an important crop of Karnataka state in India and contributing around 18 percent and 12 percent to total area and production, respectively [3].

India annually imports 3-4 lakh tonnes of pigeon pea to meet the domestic demand. Myanmar contributes 95% of the total imports due to geographical advantages. Other sources of imports are Tanzania, Kenya and Pakistan. India also exports a small quantity (8000-10000 tonnes) of pigeon pea to countries like USA, UAE, Singapore and Malaysia, but the ratio of export to import is higher and is widening over a period of time. Apart from production shortage, the crop is highly sensitive to attack by a wide range of insect pests both in the fields (at various stages of crop growth) and storage. Most of the pests attack the crop at reproductive stage causing direct losses. Diseases, insect pests and viral diseases transmitted by insects are the major bottlenecks in realising higher yields.

It is particularly difficult to estimate losses caused by pests as the crop has a good ability to compensate for defoliation up to 50% even if it occurs in the podding stage. On an average, 30-80% losses valued at 4000 - 5000 crores occur due to insect pests. During nineties in northern Karnataka, application of almost all broad spectrum insecticides failed to reduce the extensive damage (70 to 90%) and the losses incurred were to the approximate of Rs 400 crores. Similar situation with incidence varying between 90 to 100% was observed during 1997-98.

1.3 DISEASES

The major diseases causing significant losses in the south zone of India are Fusarium wilt (Fusarium udum), sterility mosaic (Pigeon pea Sterility Mosaic Virus), Phytopthora blight (Phytopthora drechslei sp. cajani) and Cercospora leaf spot.

1.3.1 Fusarium wilt

Wilting caused by *Fusarium udum* f. sp. *cajani* is characterized by yellowing and slows withering of plant. The symptoms can be observed initiating from a month after sowing or at the flowering or pod formation stage.

Figure 1: Field infected with wilt disease

The infected plants become yellow in colour followed by dropping and finally the whole plant dries up. Wilt usually appears 65-70 days after sowing and attains peak significance during the vegetative stage of crop.

1.3.2 Phytopthora blight

The disease is caused by the fungus and the disease is commonly known as stem rot of pigeon pea.

Figure 2: Close view of plant infected with Phytopthora blight

This cause seedling to die suddenly. Water soaked, irregular lesions on the leaves often cause blighting of the leaf/leaflets and younger plant. Infected leaves loss turgidity and become desiccated. Brown sunken lesions on the stem and branches causing girdling and makes the infected stem weak and leads to breakage and drying of the plant/branches.

1.3.3 Sterility mosaic

The disease is caused by pigeon pea sterility mosaic virus (PPSMV). The affected plants become light greenish in color which can be easily differentiated from dark green healthy plants. Leaves are reduced in size. Affected plants remain stunted and branch profusely, as a result of which they appear bushy. No flowers and fruits are borne on such affected plants resulting in total loss of yield. Sometimes only a few branches in the plant are affected others remaining healthy. In such cases the yield reductions are partial. The virus is not seed borne.

Figure 3: Plants showing chlorotic symptoms on leaves.

1.3.4 Cercospora leaf spots

It is caused by a fungus *Cercospora indica* , causing several types of spots on the leaves and petioles of affected plants. The spots are triangular in outline and are raised above the surface of the leaf.

Figure 4: Leaves showing irregular blackish brown Cercospora leaf spots.

2. Literature survey

N. Nandhini and R. Bhavani [19] proposed an approach to the detection and classifying of grape plant leaf diseases Downy Mildew and Powdery Mildew using an SVM classifier. The system proposes the transformation of color space from RGB to HSV model was performed, and segmentation of the images performed using the K-means algorithm. Color and texture features are extracted from segmented images and final classification with SVM classifier.

P. B. Padol and A. A. Yadav [20] proposed a model for the detecting and classification of diseases from the images of plant leaves with the help of image processing techniques. This study proposes color conversion from RGB to Lab model for segmentation of the plant leaf images with the help of K-mean clustering and median filter. From the segmented images Color, texture features are extracted and fed to the SVM for better classification.

S. Ramesh et. al.[21] proposed a model for classification of the diseases using color and shape feature extraction. Lab color space conversion is used for the color values and segmentation of images are done using k means clustering and final classification of the diseases was performed using Decision trees, SVM, KNN classifiers.

S. Ramesh et. al. [22] proposed a model for quick classification of leaf diseases using feature extraction and image processing techniques. This study proposes color space conversion from RGB o HSV model and feature extraction with the help of HOG features from the preprocessed images of papaya leaves. These features are reduced

and fed for training and classification of diseases using a Random forest classifier.

K. R. Gavhale et. al. [23] presented an approach for the detection of an unhealthy region of a citrus leaf using image processing techniques. The features are extracted from texture with Gray-Level Co-Occurrence Matrix (GLCM) and color with means of mean values. The extracted features are used for the analysis and classification of the diseases with the help of an SVM classifier.

Trong-Yen Lee et al. [12] used pretrained neural network GoogLeNet and AlexNet for leaf disease detection and used plant village dataset which is publicly available image dataset of 54,306 images of diseased and healthy plant leaves collected under controlled conditions, train a deep convolutional neural network to identify 14 crop species and 26 diseases. The trained model achieves an accuracy of 99.35%.

F. Ahmed et. al. [13] proposed system is based on the segmentation method Simple Linear Iterative Clustering to detect soybean plant leaves in the images and on visual attributes to describe the features of foliar physical properties, such as color, gradient, texture, and shape. Experimental results showed that color and texture attributes lead to higher classification rates, achieving the precision of 98.34%.

J.L. Tang et. al. [14] proposed framework for Maize leaf disease detection. It may be more difficult for inexperienced farmers to diagnose diseases than for professional plant pathologists. In this work two improved deep convolution neural network models, GoogLeNet and Cifar10, are presented to increase the recognition accuracy of maize leaf diseases and improve the traditional identification methods with long convergence times and large numbers of model parameters. During the recognition of eight kinds of maize leaf diseases, the GoogLeNet model achieves a average identification accuracy of 98.9%, and the Cifar10 model achieves an average accuracy of 98.8%.

Zheng et. al. [15] presented CNN model for disease prediction. 6 classification of tomato leaves disease have been detected including one healthy class. Tomato is a very popular vegetable in Bangladesh country as well as in the world, the main motive is to solve the diseases detection problems that the “Tomato” growers are facing nowadays in their cultivable land especially in Bangladesh.The farmers can input the symptoms in the form of images of affected tomato leaves and it will predict the diseases. The system showed up accuracy over 96.55% at the end.

Teimouri, Nima, et al. [16] proposed a semantic segmentation model based on convolutional neural networks (CNN) to segment the powdery mildew on cucumber leaf images at pixel level, achieving an average pixel accuracy of 96.08%, intersection over union of 72.11% and Dice accuracy of 83.45% on twenty test samples. This outperforms the existing segmentation methods, K-means, Random forest, and GBDT methods.

Fawakherji, Mulham, et al. [17] presented a CNN (Convolutional Neural Network) architecture which is suitable for potato major disease detection. At first, created a database for training set by means of image processing in the CNN. The experimental results show that disease judgment is 99%.

Ref.	Method	Crop	Result
[19]	K-means algorithm and SVM classifier.	Grape	91%
[20]	K-means clustering, median filter KNN classifier	Grape	88.89%
[21]	K-Means algorithm, SVM and KNN classifier.	Healthy and unhealthy plant leaf	85%
[22]	Color features and Random forest.	Papaya	
[23]	GLCM and SVM.	Citrus	95%
[12]	Deep learning models: GoogleNet AlexNet	Plant Village dataset	99.35%
[13]	Leaf segmentation based on simple iterative clustering	Soybean	98.34%
[14]	Deep learning models : GoogleNet Cifar10	Maize	GoogleNet-98.9% Cifar10-98.8%
[15]	CNN model	Tomato	96.55%
[16]	CNN model	Cucumber	96.08%
[17]	CNN model	Potato	98.9%

Table 1: Summary of existing methodology for plant leaf disease detection

Summary table 1 represents the existing methods and its result accuracy. In literature review found that there is a lack of publicly available dataset and that many authors created their own dataset. From the literature review and to the best of our knowledge it is observed that detection of diseases for pigeon pea plant and crop has not been studied. Computer vision and artificial intelligence based state of art models can be build to achieve robust plant disease detection and diagnosis system for this plant.

3. Problem Statement

Farmer's economic growth depends on the quality and quantity of the products that they produce, which relies on the plant's growth and the yield they get. Therefore, identification of disease in pigeon pea plant plays an instrumental role. In north Karnataka, the low productivity of pigeon pea is due to the effects of three major diseases such as Fusarium wilt (Fusarium udum), sterility mosaic (Pigeon pea Sterility Mosaic Virus), and Cercospora leaf spot. Manual detection of plant disease using images is a tedious job. In order to detect a plant disease at very initial stage, use of automatic disease detection technique is advantageous. The solution comes from experimenting on different artificial intelligence algorithms for the detection and classification of the diseases in the pigeon pea plant leaves image.

3.1 Objectives

The main objective of the research work is development of efficient algorithms for Pigeon pea plant disease detection and classification based on plant images. Early diagnosis of Pigeon pea plant disease and management will increase crop yield and reduce environmental loss because of herbicide. Major work is to classify the symptoms of diseases based on image processing, color transformation, segmentation, feature extraction, and classification. The research work is to classify at least two diseases of pigeon pea leguminous shrub using advance algorithms. The objectivity of this study include the following.

- ✓ To improve the quality of the input Pigeon pea plant images using image processing enhancement techniques.
- ✓ To perform segmentation of leaf images from its background.
- ✓ To perform feature extraction techniques to identify and extract characteristics that best represent a leaf image and then use feature selection techniques to obtain a reduced dimension of feature space.
- ✓ To identify a crop disease by performing selective feature selection that represent the disease.
- ✓ Analyze the performance of the developed algorithms with existing algorithms in terms of precision score, recall score, F1 score, confusion matrix, etc.

3.2 Methodology

Automatic plant disease identification and recognition techniques will be designed to assist decision making in pigeon pea plant farming. This goal is met through a series of sequential steps, namely, image enhancement techniques, extraction of ROI region, extraction of features and finally classification.

Image acquisition:

Real Pigeon pea plant agriculture field will be considered for taking diseased plant leaf images as input.

Pre-processing:

Preprocessing phase takes images as input. The input image is pre-processed to improve the quality of the image. It has a direct impact on the end result. It is used to suppress possible variations that arise during image acquisition or to remove noise or unwanted information from images without evading vital information. These variations hinder further image analysis steps. Examples include re-sizing, boundary or edge enhancement, smoothening and contrast adjustment.

Segmentation of ROI:

Efficient and effective image segmentation is important for accurate results. The technique focus on separating the Region Of Interest (ROI), that is the leaf, from its background.

Extraction of features:

The feature extraction step functions to discover various features that best represent a leaf image. Feature selection algorithm will be designed in the second stage, to select the most prominent features.

Classification:

Classification is based on the feature selected in the previous stage. Different classification algorithms will be studied and trained to enable them to detect diseases.

Result Evaluation:

Analyze the performance of the proposed techniques with existing algorithms in terms of precision score, recall score, F1 score, confusion matrix etc.

4. Outcome

Pigeon pea is a major crop in north Karnataka as it contains suitable climate requirement and soil type. Earlier, pest and disease detection was done by manual observation. This method is arduous and prone to error. In order to improve the quality of production and yield in plants, it is essential to identify the symptoms in their initial stages and treat the diseases. This also reduces the amount of pesticides spraying in the farm and reduces the soil pollution.

From the literature survey observed that there is a lack of publicly availability of dataset of pigeon pea plant. Our proposed research work involves creation of the Pigeon pea crop dataset with the help of experts and develop computer aided algorithm for pigeon pea plant disease classification. The purpose help farmers to detect and diagnose diseases at early stages thereby help achieving high crop yield and quality.

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